01. Road Damage Analysis of Kalianak Road Surabaya

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RESEARCH ARTICLE

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Road Damage Analysis of Kalianak Road Surabaya

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The road damage is a condition where the structural and functional roads are not able to provide optimal service to the traffic that crosses the road. The value of traffic and types of vehicles that cross a street is very influential in the construction and pavement design. Road damage generally occurs because of the behavior of road users, error of planning and execution, as well as inadequate road maintenance. The behavior of road users who cause damage to roads, among others, the use of a vehicle which does not comply with the class. The drainage dimension also cause damage to the road due to the rain, the drainage channels can not accommodate the volume of the rain causing flood. There is a lot of factors thats damaging roads, that is why it needs a further research. AHP (Analytical Hierarchy Process) used to determine the road damage factor. AHP is a flexible model for decision-making. The research location is at Kalianak road Surabaya. Kalianak road Surabaya is a strategic road, because it is a connecting road between the city of Surabaya with the town of Gresik. The volume of vehicles on the Kalianak road Surabaya is very high because there are a lot of factories (industrial area) along this road. From the research that has been done, the factors which influenced the damage to the roads in Kalianak Surabaya is aggregate gradation not appropriate and make large air void (weight 0.59), excessive vehicle loads (weight 0.56), bitumen content is not in accordance with the pavement thickness (weight 0.56), asphalt compaction not appropriate (weight 0.56), and bad drainage (weight 0.50).

Keywords: Roads Damage, AHP (Analytical Hierarchy Process), Kalianak Road.

1. INTRODUCTION

The good road network is the motor of the economy of a region. Instead damaged road network will hamper the economy of a region. Damaged roads make transportation flow of goods, services and people to be blocked. In addition, the resulting vehicle operating costs is larger because of damage to vehicle parts due to the load and the bumpy roads and potholes. Roads are burdened by high traffic volume and repeated load, that will decline road quality. Generally, road damage occurs because of the behavior of road users, error of planning and implementation and inadequate road maintenance.

Kalianak road Surabaya is a strategic road because this road connect the two cities, Surabaya and Gresik. The volume of vehicles on the Kalianak road Surabaya is very high because along the way there are many factories (industrial area). Rapid industrial development must be supported by appropriate road construction standards and discipline of road users. Based on the above, it is necessary to do the analysis to determine the damage of Kalianak road Surabaya.

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2. METHODOLOGY

The data collection phase:

Data Primer

—Collect the condition of road damage in the Kalianak road Surabaya according to the type of damage.

—Distribution of the questionnaire to users, managers and academics.

The data processing phase:

a. Road condition

Calculation of damage to the road conditions in accordance with the method of Bina Marga (2009), who reviewed the damage equipped with photos of the damage that occurred along the highway Kalianak.

b. Process the results of a questionnaire to determine the factors that cause damage to the Kalianak road Surabaya with AHP method.

2.1. AHP (Analytical Hierarchy Process)

AHP method is an appropriate method to determine the order of the factors that cause road damage along the Kalianak Surabaya. The steps of AHP include (Fig. 1).

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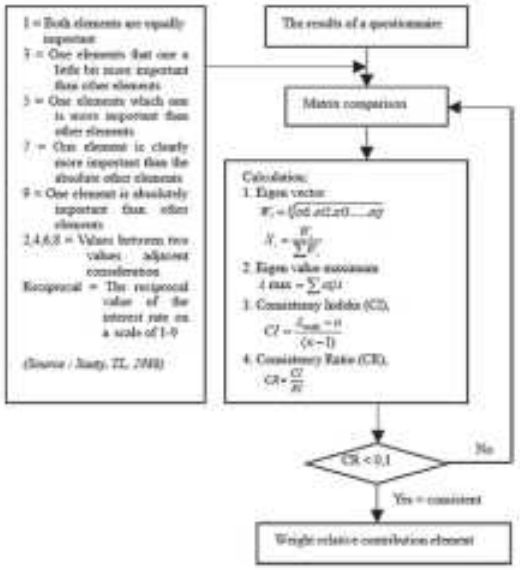

Fig. 1. Steps AHP.

Table I. Random index values.

Matrix size	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty, TL. The analytical hierarchy process, 1988.

Based on calculations using the Saaty 500 samples, if the numerical value taken at random from a scale of 1/9, 1/8, 1/7, ..., 1, 2, 8, 9 will be obtained an average consistency for the matrix different sizes, as shown in Table I.

Matrix comparison can be accepted if the value of the consistency ratio <0.1, because if more than that amount, then there should be a revision of the ratings for the level of the level of inconsistency that are too large can lead to errors.

3. EXPERIMENTAL RESULT

To get the maximum score, the survey base on Bina Marga's method, divided into three segments. From processing the survey found the percentage of damage to the road as Table II.

Table II. Percentage type of damage Kalianak Surabaya.

Category	Damage	Segments I	II	III
1	Potholes	16.97	14.73	14.59
2	Raveling/Weathering	15.29	13.87	13.49
	Alligator cracking	17.74	16.15	15.96
	Profile distortion	19.72	23.13	19.76
3	Block cracking	2.24	2.97	3.12
	Transverse crack	7.83	9.51	11.54
	Longitudinal cracking	10.70	12.13	10.26
	Rutting	9.51	7.51	11.28

Hierarchy Structure of Road Damage Factors

This hierarchy consists of 4 (four levels), as shown in Table III.

Weight Calculation Factors That Cause Road Damage

	A	B
A	1.00	1.85
B	0.54	1.00

Getting E-vector (weight)

	A	B	$(A \times B)$	$\sqrt{(A \times B)}$	E-Vector
A	1.00	1.85	1.85	1.36	0.65
B	0.54	1.00	0.54	0.74	0.35
		Amount		2.10	

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 1.85 \\ 0.54 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.65 \\ 0.35 \end{vmatrix} = \begin{vmatrix} 1.30 \\ 0.70 \end{vmatrix}$$

$$CI = (\lambda_{max} - n)/(n-1) = CI = \frac{\lambda_{make-n}}{n-1}$$

$$= CI = \frac{\lambda_{make-n}}{n-1} = (2.00-2)/(2-1) = 0.00$$

Value Ratio Index (RI) for the matrix size $n = 2$, the value of $RI = 0.00$.

Consistency Ratio $(CR) = CI/RI = 0.00 < 0.1$.

Weight Calculation Conduct Vehicle User

	C	D	E
C	1.00	2.04	4.73
D	0.49	1.00	4.53
E	0.21	0.22	1.00

Getting E-vector (weight)

	C	D	E	$(C \times D \times E)$	$\sqrt[3]{(C \times D \times E)}$	E-Vector
C	1.00	2.04	4.73	9.68	2.13	0.56
D	0.49	1.00	4.53	2.22	1.30	0.34
E	0.21	0.22	1.00	0.05	0.36	0.09
		Amount		3.79		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 2.04 & 4.73 \\ 0.49 & 1.00 & 4.53 \\ 0.21 & 0.22 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.56 \\ 0.34 \\ 0.09 \end{vmatrix} = \begin{vmatrix} 1.71 \\ 1.05 \\ 0.29 \end{vmatrix}$$

$$CI = (\lambda_{make} - n)/(n-1) = CI = \frac{\lambda_{make} - n}{n-1}$$

$$= CI = \frac{\lambda_{make} - n}{n-1} = (3.05-3)/(3-1) = 0.03$$

Value Ratio Index (RI) for the matrix size $n = 3$, the value of $RI = 0.58$.

Consistency Ratio $(CR) = CI/RI = 0.04 < 0.1$.

Table III. Hierarchy factors cause damage kalianak road surabaya.

Level 1	Level 2	Level 3	Level 4
Factors that cause road damage	Vehicle user behavior (A)	Excessive vehicle loads (C) Incompatibility with class road vehicles (D) Weighbridge function is not maximal (E)	
	Wrong planning, implementation and maintenance (B)	Bad drainage (F) (Source: P. Abhijit, P. Jalindar, 2011 and O. Agbonkhese, G. L. Yisa, P. I. Daudu, 2013)	Drainage dimension is too small (J) Inadequate drainage slope (K) Blockage of drainage by the garbage (L)
		Quality of asphalt (G) (Source: Sharad, Gupta, IOSR-JMCE)	Bitumen content is not in accordance with the pavement thickness (M) Asphalt type incompatible with environmental conditions (N) The temperature of asphalt mixing and overlay are not appropriate (O)
		Road compaction (H) (Source: D. S. Gedafa, 2008)	Asphalt compaction is not appropriate (P) Compactor type is not appropriate (Q) Pressure/weight wheel compactor is not right (R)
		Quality and aggregate grading (I) (Source: H. Mahmoud, Z. A. Belal, H. A. Abba, 2012)	Aggregate gradation is not appropriate and make large air void (S) (Source: M. O. Hamzah, M. M. Samat, K. H. Joon, and R. Muniamy, 2004) Aggregate types do not match (T) (Source: D. C. Onuoha, S. U. Onwuka, 2014) Hardness aggregates that do not fit the class path (U)

Weight Calculation Errors Planning, Implementation and Maintenance

	F	G	H	I
F	1.00	3.18	2.60	4.53
G	0.31	1.00	2.00	3.22
H	0.38	0.50	1.00	3.76
I	0.22	0.31	0.27	1.00

Getting E-vector (weight)

	F	G	H	I	$(F \times G \times H \times I)$	$\sqrt{(F \times G \times H \times I)}$	E-Vector
F	1.00	3.18	2.60	4.53	37.46	2.47	0.50
G	0.31	1.00	2.00	3.22	2.03	1.19	0.24
H	0.38	0.50	1.00	3.76	0.72	0.92	0.19
I	0.22	0.31	0.27	1.00	0.02	0.37	0.07
	Amount				4.96		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 3.18 & 2.60 & 4.53 \\ 0.31 & 1.00 & 2.00 & 3.22 \\ 0.38 & 0.50 & 1.00 & 3.76 \\ 0.22 & 0.31 & 0.27 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.50 \\ 0.24 \\ 0.19 \\ 0.07 \end{vmatrix} = \begin{vmatrix} 2.08 \\ 1.01 \\ 0.78 \\ 0.31 \end{vmatrix}$$

$$CI = (\lambda_{\max} - n)/(n-1) = CI = \frac{\lambda_{\max} - n}{n-1}$$

$$= CI = \frac{\lambda_{\max} - n}{n-1} = (4.18-4)/(4-1) = 0.06$$

Value Ratio Index (RI) for the matrix size $n = 4$, the value of $RI = 0.90$.

Consistency Ratio $(CR) = CI/RI = 0.07 < 0.1$.

Weight Calculation Bad Drainage

	J	K	L
J	1.00	1.13	5.42
K	0.88	1.00	6.35
L	0.18	0.16	1.00

Getting E-vector (weight)

	J	K	L	$(J \times K \times L)$	$\sqrt{(J \times K \times L)}$	E-vector
J	1.00	1.13	5.42	6.15	1.83	0.47
K	0.88	1.00	6.35	5.60	1.78	0.45
L	0.18	0.16	1.00	0.03	0.31	0.08
	Amount			3.91		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 1.13 & 5.42 \\ 0.88 & 1.00 & 6.35 \\ 0.18 & 0.16 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.47 \\ 0.45 \\ 0.08 \end{vmatrix} = \begin{vmatrix} 1.41 \\ 1.36 \\ 0.24 \end{vmatrix}$$

$$CI = (\lambda_{\max} - n)/(n-1) = CI = \frac{\lambda_{\max} - n}{n-1}$$

$$= CI = \frac{\lambda_{\max} - n}{n-1} = (3.01-3)/(3-1) = 0.00$$

Value Ratio Index (RI) for the matrix size $n = 3$, the value of $RI = 0.58$.

Consistency Ratio $(CR) = CI/RI = 0.01 < 0.1$.

Weight Calculation Quality Asphalt

	M	N	O
M	1.00	2.04	4.58
N	0.49	1.00	4.46
O	0.22	0.22	1.00

Table IV. Level of road damage factors.

Level 1	Level 2	Level 3	Level 4
Factors that cause road damage	Vehicle user behavior (A) (weight 0.65)	Excessive vehicle loads (C) (weight 0.56)	
		Incompatibility with class road vehicles (D) (weight 0.34)	
		Weighbridge function is not maximal (E) (weight 0.09)	
	Wrong planning, implementation and maintenance (B) (weight 0.35)	Bad drainage (F) (weight 0.50)	Drainage dimension is too small (J) (weight 0.47)
			Inadequate drainage slope (K) (weight 0.45)
			Blockage of drainage by the garbage (L) (weight 0.08)
		Quality of asphalt (G) (weight 0.24)	Bitumen content is not in accordance with the pavement thickness (M) (weight 0.56)
			Asphalt type incompatible with environmental conditions (N) (weight 0.34)
			The temperature of asphalt mixing and overlay are not appropriate (O) (weight 0.09)
		Road compaction (H) (weight 0.19)	Asphalt compaction is not appropriate (P) (weight 0.55)
			Compactor type is not appropriate (Q) (weight 0.35)
			Pressure/weight wheel compactor is not right (R) (weight 0.09)
		Quality and aggregate grading (I) (weight 0.07)	Aggregate gradation is not appropriate and make large air void (S) (weight 0.69)
			Aggregate types do not match (T) (weight 0.31)
			Hardness aggregates that do not fit the class path (U) (weight 0.09)

Getting E-vector (weight)

	M	N	O	$(M \times N \times O)$	$\sqrt[n]{(M \times N \times O)}$	E-vector
M	1.00	2.04	4.58	9.36	2.11	0.56
N	0.49	1.00	4.46	2.18	1.30	0.34
O	0.22	0.22	1.00	0.05	0.37	0.09
Amount				3.77		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 2.04 & 4.58 \\ 0.49 & 1.00 & 4.46 \\ 0.22 & 0.22 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.56 \\ 0.34 \\ 0.09 \end{vmatrix} = \begin{vmatrix} 1.71 \\ 1.05 \\ 0.03 \end{vmatrix}$$

$$CI = (\lambda_{\max} - n)/(n-1) = CI = \frac{\lambda_{\text{maks}} - n}{n-1}$$

$$= CI = \frac{\lambda_{\text{maks}} - n}{n-1} = (3.05-3)/(3-1) = 0.03$$

Value Ratio Index (RI) for the matrix size $n = 3$, the value of $RI = 0.58$.

Consistency Ratio $(CR) = CI/RI = 0.05 < 0.1$.

Weight Calculation Compaction Road

	P	Q	R
P	1.00	1.96	5.27
Q	0.51	1.00	4.85
R	0.19	0.21	1.00

Getting E-vector (weight)

	P	Q	R	$(P \times Q \times R)$	$\sqrt[n]{(P \times Q \times R)}$	E-vector
P	1.00	1.96	5.27	10.30	2.18	0.56
Q	0.51	1.00	4.85	2.48	1.35	0.35
R	0.19	0.21	1.00	0.04	0.34	0.09
Amount				3.87		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 1.96 & 5.27 \\ 0.51 & 1.00 & 4.85 \\ 0.19 & 0.21 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.56 \\ 0.35 \\ 0.09 \end{vmatrix} = \begin{vmatrix} 1.71 \\ 1.06 \\ 0.27 \end{vmatrix}$$

$$CI = (\lambda_{\max} - n)/(n-1) = CI = \frac{\lambda_{\text{maks}} - n}{n-1}$$

$$= CI = \frac{\lambda_{\text{maks}} - n}{n-1} = (3.04-3)/(3-1) = 0.02$$

Value Ratio Index (RI) for the matrix size $n = 3$, the value of $RI = 0.58$.

Consistency Ratio $(CR) = CI/RI = 0.03 < 0.1$.

Weight Calculation Quality and Aggregate Grading

	S	T	U
S	1.00	2.44	4.90
T	0.41	1.00	4.21
U	0.20	0.24	1.00

Getting E-vector (weight)

	S	T	U	$(S \times T \times U)$	$\sqrt[3]{(S \times T \times U)}$	E-vector
S	1.00	2.44	4.90	11.99	2.29	0.59
T	0.41	1.00	4.21	1.72	1.20	0.31
U	0.20	0.24	1.00	0.05	0.36	0.09
		Amount		3.85		

Getting E-value max and Consistency Ratio (CR)

$$\begin{vmatrix} 1.00 & 2.44 & 4.90 \\ 0.41 & 1.00 & 4.21 \\ 0.20 & 0.24 & 1.00 \end{vmatrix} \times \begin{vmatrix} 0.59 \\ 0.31 \\ 0.09 \end{vmatrix} = \begin{vmatrix} 1.82 \\ 0.95 \\ 0.29 \end{vmatrix}$$

$$CI = (\lambda_{max} - n)/(n-1) = CI = \frac{\lambda_{index} - n}{n-1}$$

$$= CI = \frac{\lambda_{index} - n}{n-1} = (3.06 - 3)/(3-1) = 0.03$$

Value Ratio Index (RI) foe the matrix size $n = 3$, the value of $RI = 0.58$.

Consistency Ratio $(CR) = CI/RI = 0.05 < 0.1$.

4. CONCLUSIONS

The results conclusions, namely:

1. The type of damage that occurs along the Kalianak road Surabaya is a profile distortion, alligator cracking, potholes/hole, ravelling/weathering, longitudinal cracking, rutting, transverse crack, block cracking.
2. Factors that cause road damage is vehicle user behavior (weight 0.65) and errors of planning, implementation and maintenance (weight 0.35).
3. Road damage factors of the vehicle user behavior caused by excessive vehicle load (weight 0.56), incompatibility with class road vehicles (weight 0.34), and weighbridge function is not maximal (weight 0.09).
4. Road damage factors of wrong planning, implementation and maintenance is bad drainage (weight 0.50), quality of asphalt (weight 0.24), road compaction (weight 0.19), quality and aggregate grading (weight 0.07).
5. Road damage factors of bad drainage is drainage dimension too small (weight 0.47), inadequate drainage slope (weight 0.45) and blockage of drainage by the garbage (weight 0.08).
6. Road damage factors of quality of asphalt is bitumen content not in accordance with the pavement thickness (weight 0.56), asphalt type incompatible with environmental conditions (weight 0.34), the temperature of asphalt mixing and overlay are not appropriate (weight 0.09).
7. Road damage factors of road compaction is asphalt compaction not appropriate (weight 0.56), compactor type is not appropriate (weight 0.35) and pressure/weight wheel compactor is not right (weight 0.09).
8. Road damage factors of quality and aggregate grading is aggregate gradation not appropriate and make large air void (weight 0.59), aggregate types do not match (weight 0.31) and hardness aggregates that do not fit the class path (weight 0.09).
9. The factors that most influence on the damage in the road Kalianak Surabaya is aggregate gradation not appropriate and make large air void (weight 0.59), excessive vehicle loads (weight 0.56), bitumen content is not in accordance with the pavement thickness (weight 0.56), asphalt compaction not appropriate (weight 0.56), and bad drainage (weight 0.50).

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